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DETERMINATION OF EXACT ORIENTATION RELATIONSHIPS BETWEEN MARTENSITE AND AUSTENITE IN STEELS BY MICRODIFFRACTION

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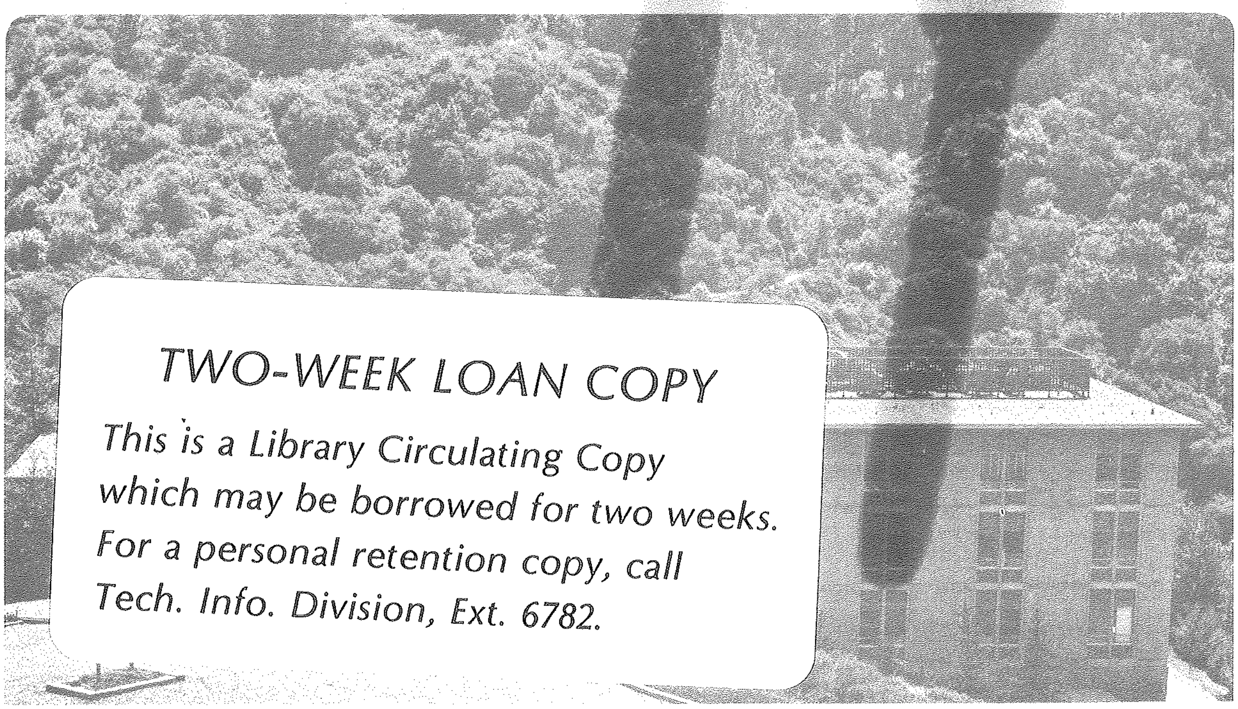

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DISCLAIMER

DETERMINATION OF EXACT ORIENTATION RELATIONSHIPS BETWEEN MARTENSITE AND AUSTENITE IN STEELS BY MICRODIFFRACTION

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A significant number of investigations have been performed on the determination of orientation relationships (OR) in high carbon, plate-martensitic steels.[1] However, very little is known on the exact nature of ORs in technologically important lath martensitic steels. In the present study, in a series of low alloy steels with carbon contents between 0.1-0.4wt%, the existence of retained austenite as thin films (∿200Å thick) around the martensite lath boundaries, makes it possible to do direct crystallographic analysis between martensite and austenite by microdiffraction.

The most commonly observed orientations for lath martensite-retained γ are $<111>_{\alpha'}//<110>_{\gamma}//<100>_{\alpha'}$. Fig. 1 shows an example of a highly symmetric SAD pattern which was interpreted as follows:[2] Considering only one martensite lath at a time, the $<111>_{\alpha'}$ and $<110>_{\gamma}$ combination corresponds to Kurdjumov-Sachs (K-S) OR, and $<110>_{\alpha}$ and $<100>_{\gamma}$ corresponds to Nishiyama-Wassermann (N-W) OR. The coexistence of these two relationships may be taken as evidence that as many variants as necessary occur to provide maximum flexibility for martensite nucleation.[2] This is also shown in Fig. 2 where the SAD pattern exhibits at least four superimposed diffraction patterns belonging to different zone axes. Careful indexing (Fig. 2b) indicates the following crystallography and ORs: $(111)_{\gamma}//(110)_{\alpha}$ and (i) $[\bar{1}2\bar{1}]_{\gamma}//[\bar{2}\bar{1}\bar{1}]_{\alpha'}$ (K-S), (ii) $[\bar{1}2\bar{1}]_{\gamma}//[\bar{3}\bar{1}\bar{1}]_{\alpha'}$ (K-S), (iii) $[\bar{1}2\bar{1}]_{\gamma}//[0\bar{1}1]_{\alpha'}$ (N-W).

The interrelation between these commonly observed ORs are as follows: $(111)_{\gamma}$ within about 1° of $(101)_{\alpha'}$, and $[0\bar{1}\bar{1}]_{\gamma}$ at some angle θ from $[11\bar{1}]_{\alpha}$ where θ varies from 0° to 5°. The value of θ for K-S, N-W, and for another OR, i.e., Greninger-Troiano (G-T), is 0°, 5.26°, and 2.5°, respectively. During the examination of conventional SAD patterns, at 100kV, the crystallographic information can be obtained from an area of $\sim 2\mu m$ size but with an ambiguity of $\sim 5°$. As a result it is very difficult to determine which OR is being obeyed. Therefore, it becomes essential to use converging beam electron diffraction methods[3] with small probe sizes, e.g., 400Å, which enables precise, $< \pm 0.5°$, orientation determination.

The stereographic projection analysis of such an experiment, shown in Fig. 3, is as follows: The left hand side: Lath A; Beam direction, $\vec{B}$, parallel to $[\bar{1}01]_{\gamma_\ell}$, or 6.8° from $[1\bar{1}1]_{\alpha'_a}$, and $(111)_{\gamma_\ell}//(101)_{\alpha'_a}$, so $[01\bar{1}]_{\gamma_\ell}$ is 3.5°, θ_1, from $[11\bar{1}]_{\alpha'_a}$. Lath B; $\vec{B} \simeq [0\bar{1}1]_{\gamma_\ell}$, or 2.9° from $[0\bar{1}0]_{\alpha'_b}$, and $(111)_{\gamma_\ell}//(101)_{\alpha'_b}$, hence $[\bar{0}1\bar{1}]_{\gamma_\ell}$ is 2.0°, θ_2, from $[11\bar{1}]_{\alpha'_b}$. The right side: Lath B; $\vec{B} = [01\bar{1}]_{\gamma_r}$, or 2.4° of $[0\bar{1}0]_{\alpha'_b}$, and $(111)_{\gamma_r}//(101)_{\alpha'_b}$, and hence $[01\bar{1}]_{\gamma_r}$ is, 3.0°, θ_3, from $[11\bar{1}]_{\alpha'_b}$. Finally, for lath C; $\vec{B} \simeq [0\bar{1}1]_{\gamma_r}$, or 3.4° of $[\bar{1}\bar{1}\bar{1}]_{\alpha'_c}$, $(111)_{\gamma_r}//(101)_{\alpha'_c}$, and hence $[01\bar{1}]_{\gamma_r}$ is 6.0°, θ_4, from $[\bar{1}\bar{1}1]_{\alpha'_c}$. Therefore, it is clear from the θ values that the ORs shown are not exactly K-S or N-W, but rather that they lie between them, and actually cluster around G-T OR. An hypothesis can be advanced here that the OR between the adjacent laths and retained-γ, instead of being fixed values, may be those with angles θ of the exact OR, i.e., a continuous range of OR's may develop between the individual laths in a group and retained-γ in a single packet.

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FIGURE LEGENDS

Fig. 1. (a) BF, (b) DF (Ret-γ), (c) SAD pattern, and (d) stereographic analyses on 0.1Cwt% alloy.

Fig. 2. (a) SAD and (b) indexed patterns taken from the region shown in the inset (0.3C steel).

Fig. 3. Analysis of ORs in 0.1C alloy. (a) BF and (1) through (6) CBED patterns from the corresponding regions in (a).

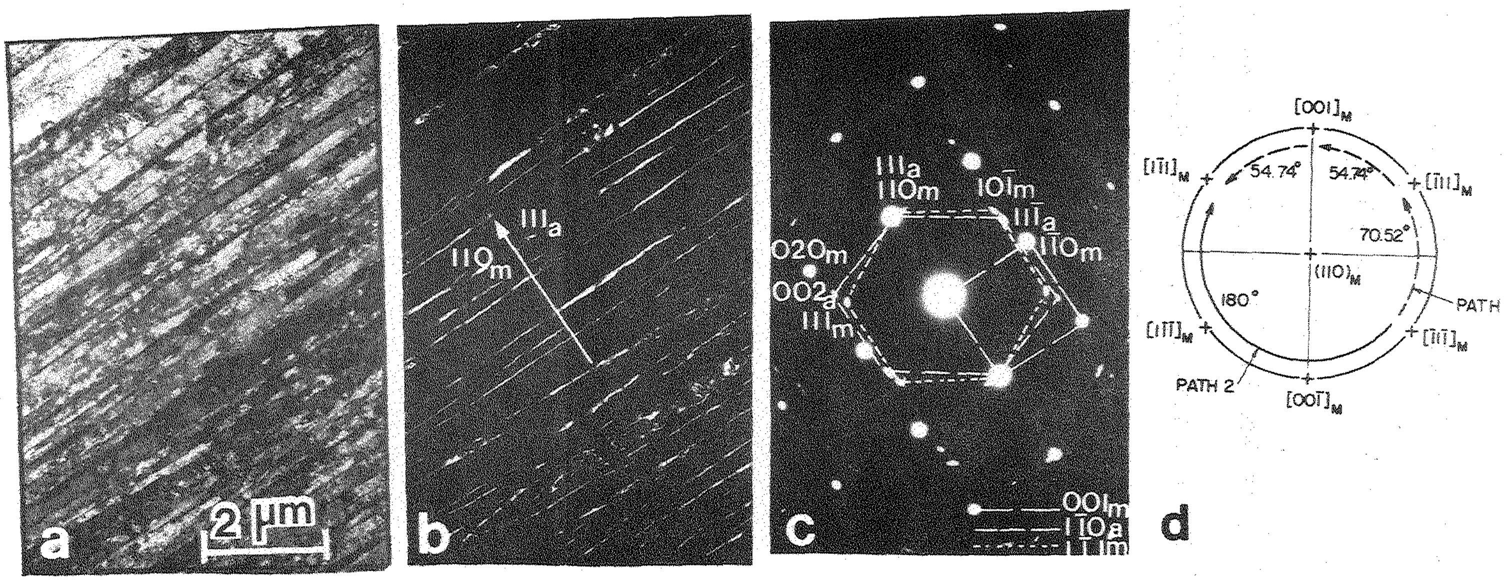

Fig. 1

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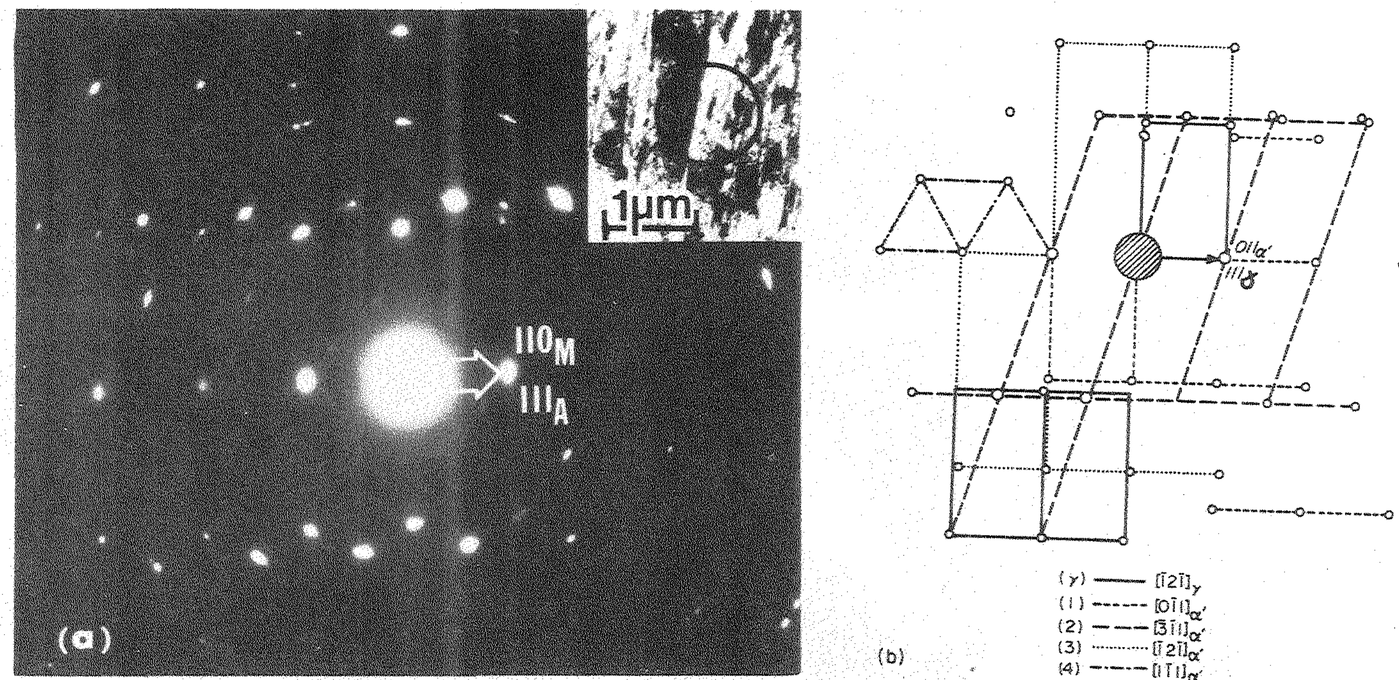

Fig. 2

XBB812-1707

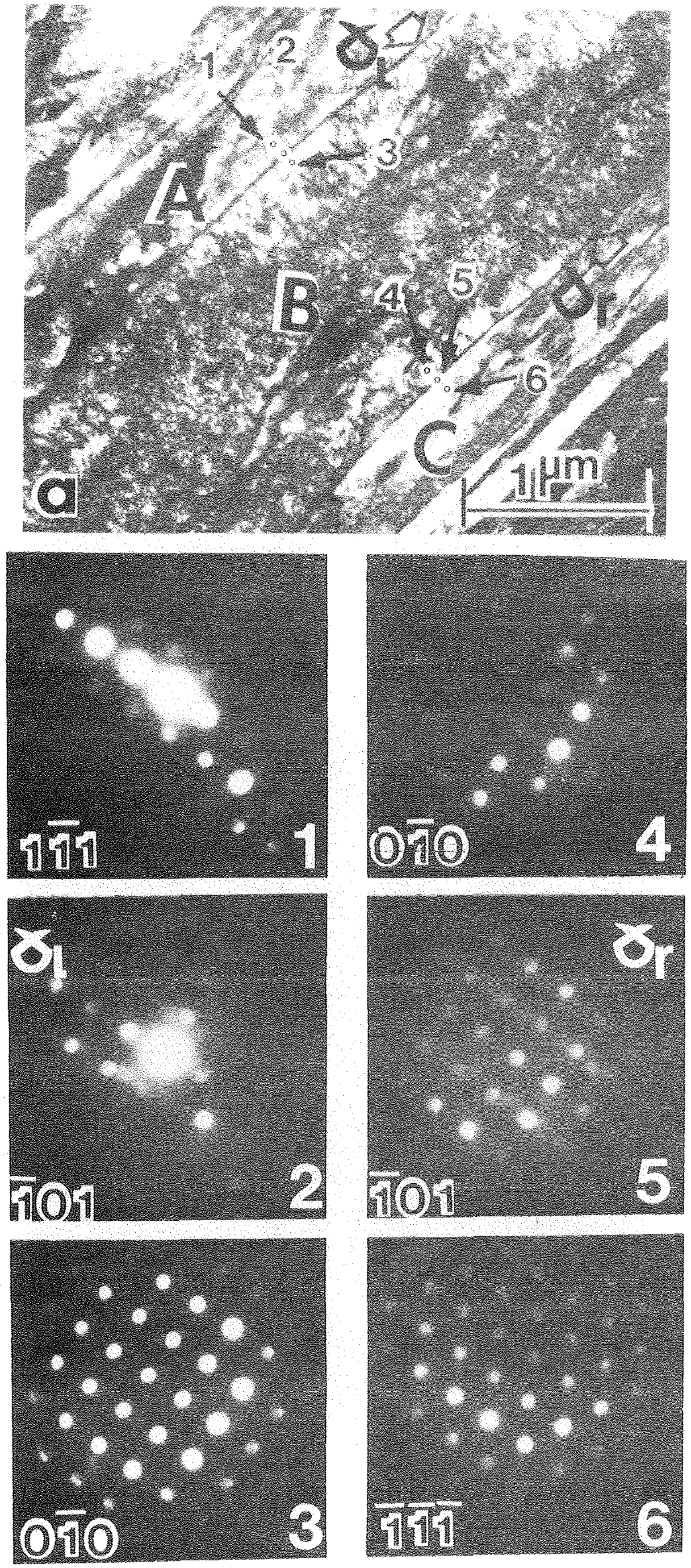

Fig. 3 XBB812-1708